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A REPORT ON THE COASTAL WATERS OF LABRADOR.

Based on Explorations of the "Chance" During the Summer of 1926.

By C. Iselin.

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Introduction.

The north westernmost corner of the Atlantic Ocean, because of its bottom conformations and closed current system, forms a favorable unit for oceanographic study. This body of water is bounded on the northeast by Greenland, on the northwest by Baffin Land, on the west by Labrador and Newfoundland, and is limited on the south by the Grand Banks. A study of the bottom contours of the region (Schott 1912) shows that this sea has the topography of a gulf, for a long, moderately shallow ridge extending in a southwesterly direction from Iceland limits the deepest (greater than 4000 meters) connection with the bottom waters of the North Atlantic to a comparatively narrow channel east of the Grand Banks. All other outlets of this basin, for example Hudson Strait and Kennedy Channel, are shallow and narrow. A counter-clockwise system of currents marks off even better than do the submarine topographic boundaries, the limits of this body of water. The icy Labrador Current forms 1600 miles of its western boundary. The much warmed North Atlantic Drift, sweeping in an arc from Flemish Cap towards Cape Farewell, may be taken as the southeastern boundary, and the West Greenland Current completes the circuit.

This region is an important one for oceanographic study because the Labrador Current provides a vast discharge of arctic water into the North Atlantic. Not only are great masses of icy water being continually transported by it to relatively low latitudes, but also quantities of arctic plankton are spread southward and finally left to die in the warmer waters south and east of the Grand Banks. Nevertheless, exact physical observations have been scanty for the waters of this region, and accordingly little attempt has been made to study its circulatory system in detail. Many ships sailing up into Baffin Bay have made surface observations and likewise much is known about the movement both of the bergs and of the pack ice, but subsurface observations, so necessary in modern oceanographic procedure, have been sadly lacking until very recently (Smith 1928, Riis-Cartensen, 1929).

Physical observations over the continental shelf and especially in the bays and inlets of the region are interesting from the biological point of view, because they provide the exact temperature and salinity of the water which swarms with so much life. Very few systematic plankton investigations have been made along the Labrador coast, especially north of Hamilton Inlet, and nothing at all is known about the chemistry of the water there. Often it is only through a knowledge of the current system of a region that the distribution of marine life can be accounted for.

It was with the view of making a beginning at the study of these phases of the northern sector of the Labrador Current, and its plankton, that the schooner "Chance" in the summer of 1926 undertook a cruise along the Newfoundland and Labrador coasts as far north as Cape Chidley. Since then (summer of 1928) the U. S. Coast Guard patrol boat "Marion" has made an extended physical survey of the circulation of the Labrador Sea, the results of which are now in the process of preparation (Smith 1928). And that same summer Commander E. Riis-Cartensen on the "Gothaab" made a general oceanographic survey of Davis Strait northward into Baffin Bay (Riis-Cartensen, 1929). The observations of the "Chance" on the Labrador Current therefore provide material which, when combined with the much more complete work of the "Marion," and "Gothaab" can be used for the study of annual variations. Furthermore, the "Chance" made some investigations of the conditions in the bays and fiords of the Newfoundland and Labrador coasts, where the "Marion," because of the extended nature of her cruise, could not stop. This report aims to present, as nearly as possible, the state of knowledge of the circulatory system of the Labrador Sea before the "Marion" began her work in 1928.

The work of the "Chance" included three cross sections of the Labrador Current, the first off Cape Race, Newfoundland, running out in a southeasterly direction as far as the shoal waters of the Grand Banks; the second off Sandwich Bay, Labrador (Lat. 54°), and the third off Nachvak Bay, Labrador (Lat. 59°). These last two extended over a hundred miles from the shore. Investigations were also made in the waters of White Bay, Newfoundland, and in Seglek, Nachvak, and Ryan's Bay, Labrador, these being chosen as representative of the different types of fiords which indent the northeast coast of subarctic America.

The schooner was equipped with a small winch and could collect subsurface water samples down to about 600 meters. Forty stations

were occupied for temperature and salinity observations, while tow netting was carried on with #20 bolting silk net at eighteen surface stations. At a number of other points a much coarser and larger net was used at various depths, but this latter material has not yet been fully studied. On shore one of the members of the expedition made a fairly complete botanical collection which has already been reported on (Woodworth 1927).

The water bottles used were of the Ekman type. The thermometers were made by Negretti and Zambra of the latest design, equipped with auxiliary thermometers. The salinity of about half the water samples collected was found by the usual method of chlorine titration. That of the other half was calculated with the help of the new electrical apparatus recently developed for use on the Ice Patrol ships (U. S. Coast Guard, 1924). This was a considerable saving of time, not to mention the increase in accuracy.

In the work of preparing for the trip and in the writing of this report Dr. H. B. Bigelow has been a constant advisor and teacher

The "Chance" Profiles.

The Gully off Cape Race, Newfoundland. On the morning of July 20, 1926, after getting a sounding of 40 fathoms on the Newfoundland side of the Grand Banks, a station was made and the schooner then headed northwest for Cape Race, 40 miles away. Four stations were made about 10 miles apart, while crossing the gully. This profile was undertaken partly because of a report (Le Danois 1924) of abnormally low water temperatures to the westward of Cape Race (between Green Bank and St. Pierre Bank), and partly to give the crew practice in using the apparatus.

There exist several sets of previous observations on the waters of this gully. In 1914 the Ice Patrol (U. S. Coast Guard 1915, p. 54) made three stations between the Grand Banks and St. Johns, which, as they were occupied July 16–17, are directly comparable with the observations made by the "Chance" so far as the season of the year is concerned. A much more complete section, made by the Ice Patrol in April, 1924 (Smith, 1924) gives a picture of conditions earlier in the spring. Besides these, two stations were made by the "Scotia" (Matthews 1914) in the gully in 1913, and one by the "Michael Sars" (Murray and Hjort 1912) in July 1910. A comparison with these earlier records indicates that the temperatures and salinities encountered there by the "Chance" were in no way exceptional for the time of year.

Our profiles for temperature (Fig. 1) and for salinity (Fig. 2) show the gully filled with water which was apparently of Labrador Current origin, for below 40 meters all the water was colder than 0° C (minimum temperature −1.36°) and of a salinity between 32.5 and 33.5

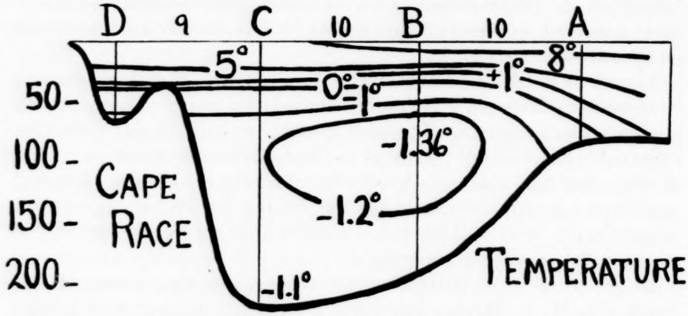

FIGURE 1. Temperature profile across the gully off Cape Race, Newfoundland.

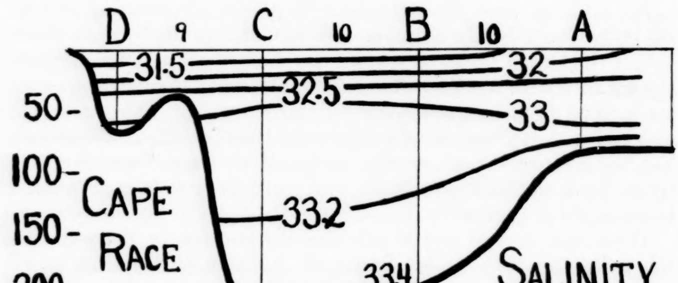

FIGURE 2. Salinity profile across the gully off Cape Race, Newfoundland.

parts per thousand. The surprisingly low temperatures (−2° to −4°) found by Le Danois were in a region about 120 miles southwest of the "Chance's" stations. If his observations are correct it does not seem possible that the Cape Race gully is the path by which such icy water came from the north. For when the temperatures and salinities are translated into densities (Fig. 3) no gradient appears which could cause

water to flow in from the northeast. This conclusion is corroborated by the fact that dynamic calculations by the usual method (Smith 1926) based on these data fail to show any gradient for a current through the gully in either direction. It is true that various earlier observations have indicated a southwesterly drift through this gully. Each spring, for example, bergs are carried around Cape Race and up into Placentia Bay. Similarly, a series of current-meter readings made by W. Bell Dawson (1906), ten miles east of Cape Race, show a dominant southwesterly drift which he considered a branch of the Labrador Current. But it has also been reported (Dawson 1906, p. 23) that this movement of water from the Labrador Current to the south-

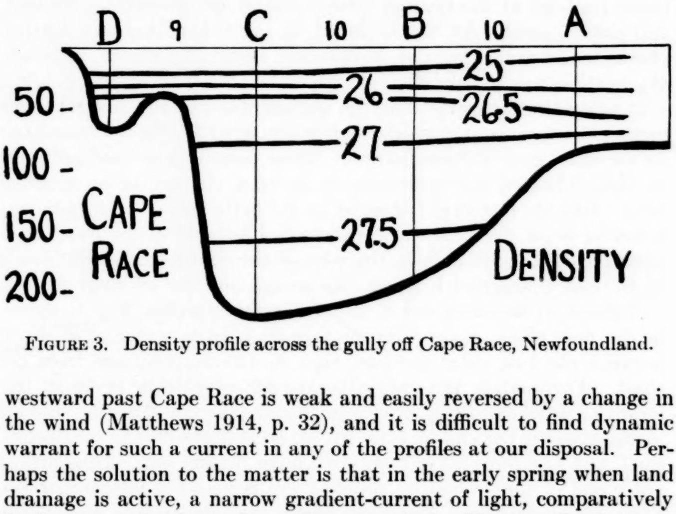

FIGURE 3. Density profile across the gully off Cape Race, Newfoundland.

westward past Cape Race is weak and easily reversed by a change in the wind (Matthews 1914, p. 32), and it is difficult to find dynamic warrant for such a current in any of the profiles at our disposal. Perhaps the solution to the matter is that in the early spring when land drainage is active, a narrow gradient-current of light, comparatively fresh, water develops along this part of the Newfoundland coast. Such a current would naturally be pressed close to the shore by the effect of the earth's rotation and might carry the bergs, of Labrador Current origin, around the cape and up into the bays on the south coast. In short, the arctic water found by the "Chance" in the gully during July was not under the influence of an active dynamic gradient; rather it represented a slow creep from the east, from the Labrador Current, which is constantly bringing icy water southward.

Sandwich Bay Sector. The first of our two sections of the Labrador

Current, proper, ran out at approximately right angles to the general trend of the coast from a point twenty miles south of Hamilton Inlet. It was hoped that we would thereby obtain a cross section of the fresh coastal waters flowing southward along the shore, as well as of the Labrador Current itself, further at sea. After sailing eastward for 140 miles, a sounding showed no bottom at 400 fathoms, so knowing that we were then outside the edge of the continental shelf, and since the surface temperature of the water had risen from 2° C to 7° C, we headed back to get a cross section of the icy band on the continental shelf. The nine stations were all made while sailing on one course back towards the coast (July 28th to 30th); and since we secured a lucky land-fall at the Gannet Islands, which are accurately charted, and since a good sight was obtained on the second day as a further check, it is certain that our stations are accurately placed, although the weather was mostly cloudy.

It proved unfortunate that the section was not run several miles further north, since it crossed a deep gully, of which the few soundings on the chart gave little indication. These soundings are not sufficient to show whether this depression is an open channel or an inclosed bowl. But the fact that the water in the gully below 300 meters was found to be of the same temperature and salinity as the water at a corresponding depth outside the edge of the continental shelf, points to an open connection between this trough and the off shore waters.

A glance at the outer end of this temperature-profile (Fig. 4) shows, in the first place, a very abrupt transition from water of 0° to 4° between our two outer stations, that is, 120 to 135 miles from the coast. Fortunately the only other profile previously made in this locality (Matthews 1914), covers just this region, the "Scotia" having made, towards the end of June 1913, two stations on the continental shelf, and one other, over a hundred miles further out. Thus for the outer end of the "Chance" profile there is material for comparison. From his observations Matthews places the temperature wall within three miles of its location on our profile. Secondly, in both the "Chance" and "Scotia" sections the coldest water (−1°) extends outward as a thin tongue at a depth of between 40 and 100 meters, as is shown by the bulging outward at these depths of the isotherms which make up the temperature wall. Thirdly, both profiles show the water 2.5° warmer at the bottom of the gully than on a level with its rims.

For the inshore waters off this sector of the coast, the observations of the "Scotia" affords no comparisons, as she made no station within 50 miles of the shore. The "Chance" profile (Fig. 4) shows the coldest

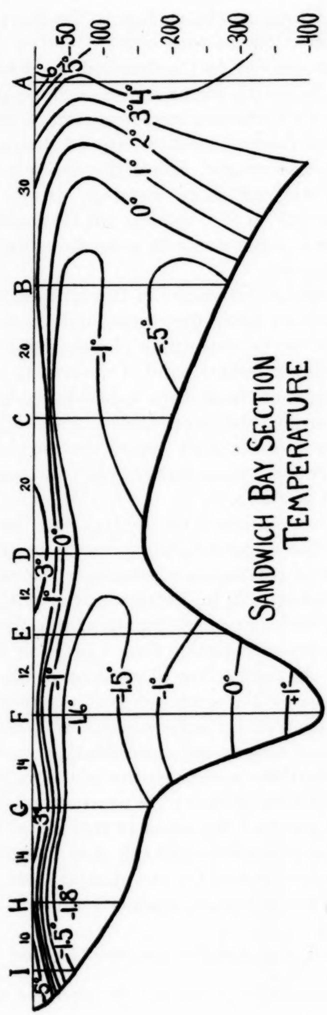

FIGURE 4. Temperature profile off Sandwich Bay, Labrador. The distances between stations are indicated in miles and the depths in meters.

water ($-1.5°$ to $-1.8°$) approaching close to the coast and extending outward at intermediate depths to a point over the eastern edge of the gully. Another interesting fact is that inshore, where the water is less than 180 meters in depth, the profile shows no warming near the bottom. True Labrador Current water, being relatively light, spreads out on the surface and rarely extends in any of the available profiles more than 200 meters downward. Below this depth a certain amount of mixture with warmer, off shore water is always evident. The warmer surface water (3° to 8°), coming out of Hamilton Inlet, extended at this time to a point about 18 miles from the coast and to a depth of about 25 meters.

To sum up, there can be recognized in this temperature profile four different types of water: first, the warm, relatively fresh coastal stream, given its character by the outflow of river water from Hamilton Inlet; second, the icy intermediate band of the true Labrador Current, which had presumably come from some region far to the north of this profile; third, the warmer and more saline mass of the off shore, North Atlantic, water which is truly oceanic in character; and finally, the bottom water over the deeper parts of the continental shelf which is a mixture of these last two.

These conclusions are confirmed by the fact that the Sandwich Bay salinity-profile (Fig. 5) corresponds closely to the temperature profile. Thus the isohaline of 34 per thousand, marking the outer edge of the truly arctic water, corresponds in position to the isotherm of 0°.

The corresponding density profile (Fig. 6) of the superficial stratum shows comparatively regular density lines with their inshore ends all slanting downward. An instructive illustration of the dynamic slope is afforded by the curve for 27,* since it cuts the surface near station A, but lies 100 meters deep at its inshore end. If a density wall then existed, it was situated further off shore than this section extended. It is also significant that the density curves at the outer stations show a decided slant at even a depth of 300 meters. Thus the density profile indicates first, that all the water in this sector had an impulse for southerly movement; second, that this flow was fairly evenly distributed over the whole width of the continental shelf; and third, that the coastal stream of much fresher, warmer water was really a current within a current.

Dynamic analysis of the data for temperature and salinity corrob-

* Densities are at temperature *in situ* and are expressed as specific gravity minus 1. times 1000.

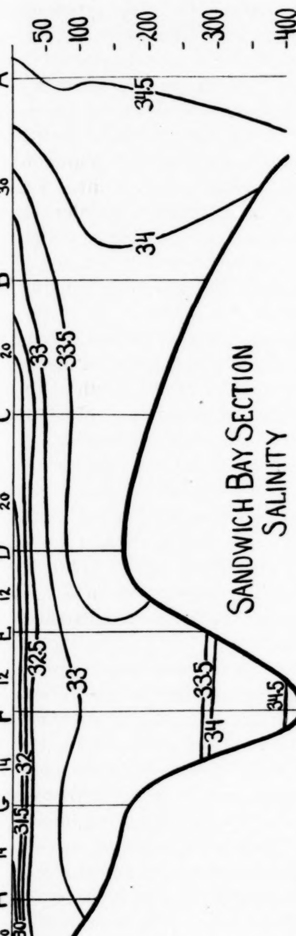

FIGURE 5. Salinity profile off Sandwich Bay, Labrador.

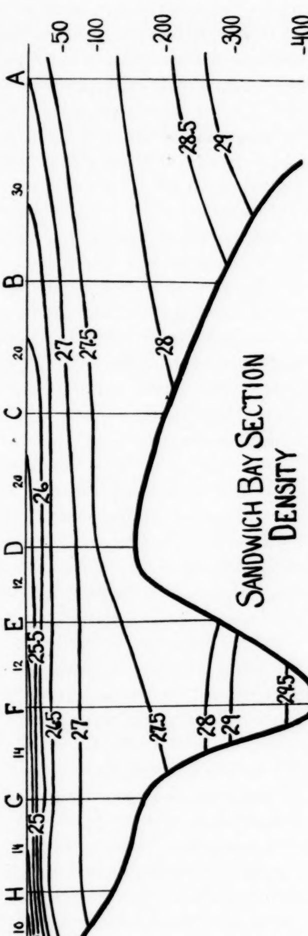

FIGURE 6. Density profile off Sandwich Bay, Labrador.

orates this interpretation of the profile, the calculated gradient calling for a comparatively uniform dynamic slope across the entire section, which is shown in horizontal projection in Figure 7. From station A to station E the gradient was 20.9 dynamic centimeters in a distance of 82 miles which points to an average current of about .3 knots. Calculations of the details of the velocity of the current off Sandwich Bay by the method developed by Jacobsen and Jensen (1926) in their investigations of the Fareo-Shetland Channel, is not satisfactory, first, because of the bottom conformation and second, because the profile shows no water that can be taken as a motionless, base plane. If the stations had been twice as many in number, and especially, if one other had been located between E and F, this method probably could have been applied with positive results.

Nachvak Sector. The relationship of the southern sector of the current to a more northern one, both as to the absolute distribution of temperature and salinity, and as to dynamic impulse toward a southerly flow, is brought out by comparing the above conditions off Sandwich Bay with our Nachvak profile, 311 miles further north.

On August 11 the "Chance" began a line of stations running off shore from Nachvak Fiord in a direction nearly at right angles to the general trend of the coast. The bottom was found there to slope gradually from 120 meters near the land to 300 meters at the edge of the continental shelf, 75 miles off shore. The current along the northern Labrador coast flows, therefore, over a narrower and shallower platform than off Sandwich Bay. Omitting mention of the fiord, which is discussed below (Page 24), it will be noticed (Fig. 8) that at the time of the "Chance's" observations the coldest water (below 0°) conforming to the relative width of the continental shelf, was about 45 miles narrower than off Sandwich Bay, water with its whole mass, surface to bottom, as warm as 4° being encountered on the Nachvak profile in the region of Station I, only 89 miles from the coast.

Our two sections of the Labrador Current agree in the following important respects. In neither case does the coldest water quite reach the coast line, being separated from the latter by a band of fresher, warmer, land-drainage water close in along the shore. In summer it is probable that this long-shore current runs inside of the arctic water along the whole length of the outer Labrador coast. In both profiles the coldest water extends off shore as a tongue with the lowest readings at a depth of from 30 to 100 meters, and in the region of sharp thermal transition, the water warms by about 4° at all depths in a distance of but 20 miles.

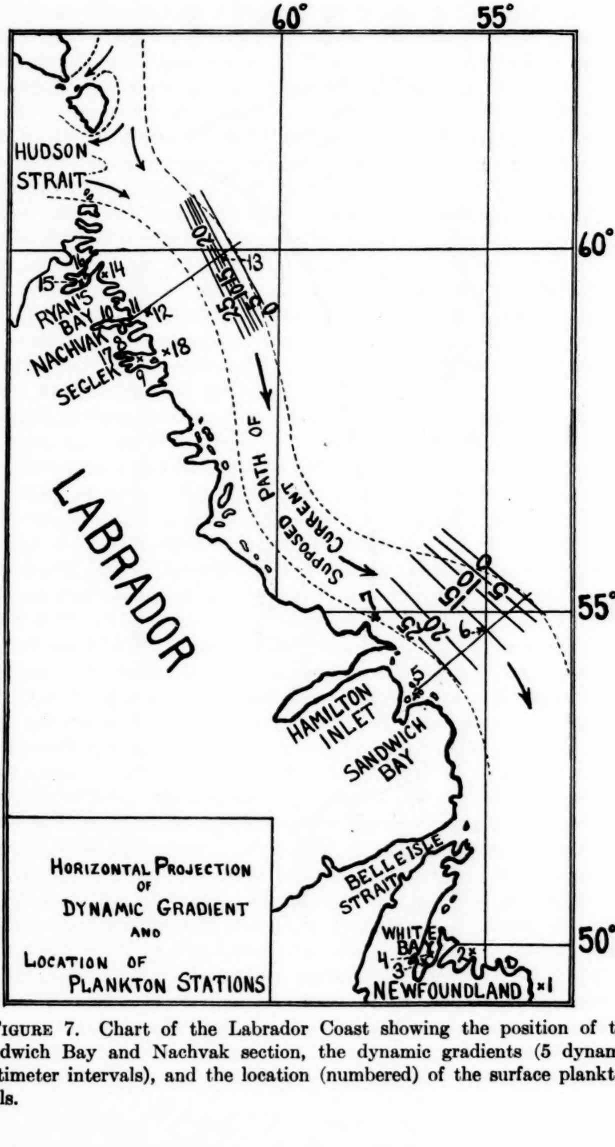

FIGURE 7. Chart of the Labrador Coast showing the position of the Sandwich Bay and Nachvak section, the dynamic gradients (5 dynamic centimeter intervals), and the location (numbered) of the surface plankton hauls.

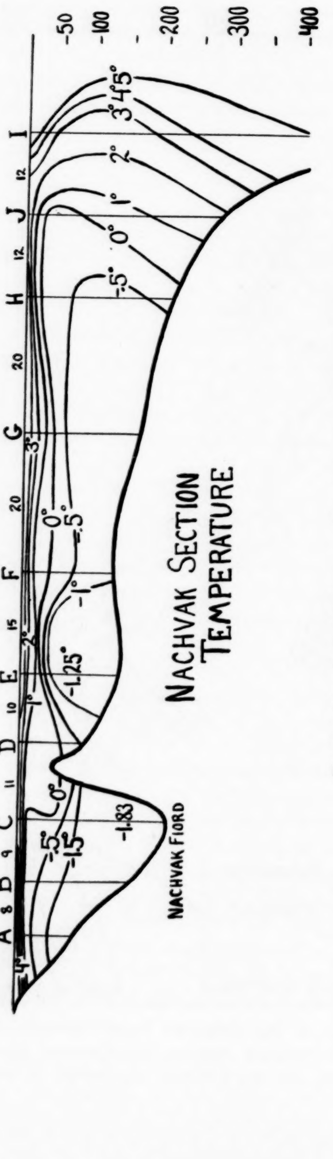

FIGURE 8. Temperature profile off Nachvak Bay, Labrador.

Although the agreement between the Sandwich Bay and Nachvak profiles is so close in a general way, there are several minor points of difference reflecting local causes. Thus the four inner stations on the northern section show no rise in temperature near the bottom. Had the continental shelf of Nachvak averaged as deep as it did off Sandwich Bay, it is probable that the lightness of the icy waters would have caused warmer waters to be drawn in underneath from off shore. Secondly, no water in the Nachvak section was quite as cold as the coldest water off Sandwich Bay, although lower temperatures are usually to be expected in higher latitudes. This apparent anamoly is to be explained by the fact that the Nachvak profile represents a considerably more advanced stage in summer warming. Thirdly, in the region of sharply slanting isotherms between the two outer stations, the strength of the current no doubt caused screwing movements and eddies, explaining the unusually low surface temperatures encountered there. Further inshore, the water layers were more stable, and convectional currents hindered by the stronger Archomedian forces. Therefore the surface shows more solar warming there because the sun's heat is but little communicated downward.

Finally, inshore, in the region of station D we see on the Nachvak profile water which is practically homogeneous from top to bottom. This last is best interpreted as reflecting the southward movement of water which has been well churned by the strong tides of Hudson Strait, as well as in passing over the broken line of shallow reefs that run off shore for 15 miles just north of this section. Any water which rounds Cape Chidley must pass over this reef and become well mixed by the time it reaches the mouth of Nachvak Fiord. Thus we have illustrated in this short section very striking thermal differences, giving a typical picture of the temperature conditions in a coastal current with the advance of summer in high latitudes.

The salinity profile (Fig. 9) off Nachvak shows as definite a correspondence between temperature and salinity as do the Sandwich Bay profiles though with the salinities somewhat lower especially near the bottom. This difference is the result of the shallower continental platform, for it is in small amounts only that water of greater salinity than 33 parts per thousand can overflow the continental shelf here. Probably the incorporatoin of Hudson Bay water, which rounds Cape Chidley just north of this sector, also lowers the salinity of this part of the current and may account for the fact that the isohaline of 32 per thousand lies at a greater depth than further south. At the outer edge of the current off Nachvak, the position of the isohaline of 34

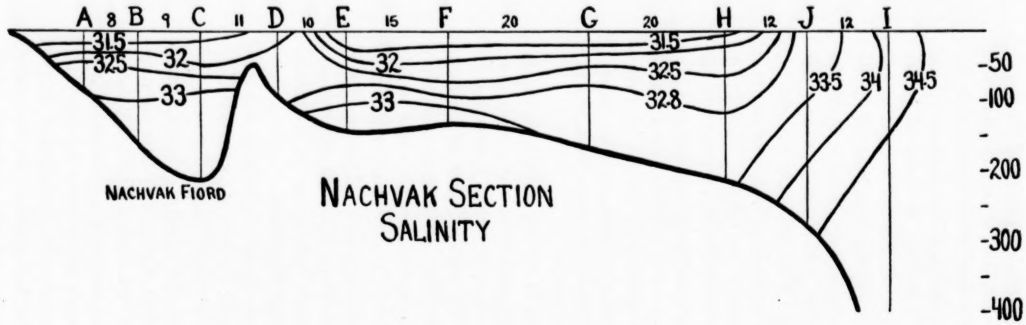

FIGURE 9. Salinity profile off Nachvak Bay, Labrador.

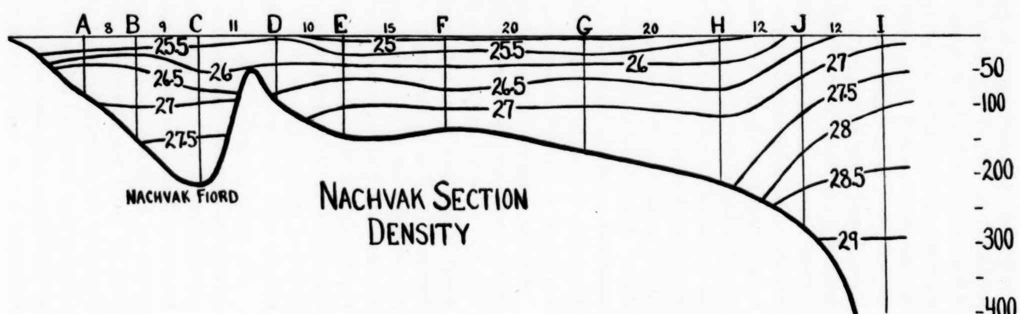

FIGURE 10. Density profile off Nachvak Bay, Labrador.

per thousand corresponds to the dividing line between water colder and warmer than 3°.

Although the distribution of salinity and temperature off Nachvak so much resembles that off Sandwich Bay, the combination of these factors in a density profile (Fig. 10) shows a different distribution of current-propelling forces. In this case all the curves are approximately horizontal as far out as station H, but show an abrupt tilting upward between stations H and I in the upper 250 meters of water. This indicates that the strength of the current occupied a band 25 miles wide, centering about 60 miles off shore.

As might be expected, on this profile the dynamic gradient all lay between the outer three stations, with a rise of 24.8 dynamic centimeters from station I to station H, but no appreciable gradient from station H in to the coast. At the surface between the two outer stations, the calculated average velocity is .67 knots. Between station J and H the average velocity is greater (.98 knots) and these figures can be considered reasonably accurate as at 300 meters the base plane between the two outer stations was dynamically level.

Horizontal projection of the dynamic gradients found from the Sandwich Bay and Nachvak profiles (Fig. 7) suggests a fanning out and slowing down of the current from north to south. Whether or not the narrowness and intensity of the current along the northern sector of the coast is a permanent phenomenon is an open question. The water coming out of Hudson Strait may be the cause.

Davis Strait Sector.

A set of observations made by Dr. Hjort in 1923 (Conseil International, 1925) across the narrows of Davis Strait show the arctic current just as it leaves Baffin Bay at a point 427 miles north of the "Chance's" most northern section. Six stations were taken, four of which were in line across the narrowest part of the Strait (Lat. 66° 31′ N). A fifth lay 120 miles further north and a sixth 30 miles south of the section. These last two can justly be interpolated since they are situated at about the same distance from the Greenland shore, and since the result fits well with the other four. This interpolated station is desirable because if four stations are used in the section there is left blank a distance of 86 miles between station 9, in the middle of the strait, and station 16 on the Greenland coastal bank. From the interpolated station, we can gain an idea of the bottom waters on the eastern side of the strait.

The temperature profile (Fig. 12) shows Arctic water (colder than 0°) filling the western half of the strait between the depths of 40 and 150 meters, and spreading out to the eastward in a thin tongue, just as was found further south by the "Chance." Pressed close to the Cumberland Island shore we see a core of $-1.5°$ water overlying somewhat higher $(+1°)$ bottom temperatures. At the surface the

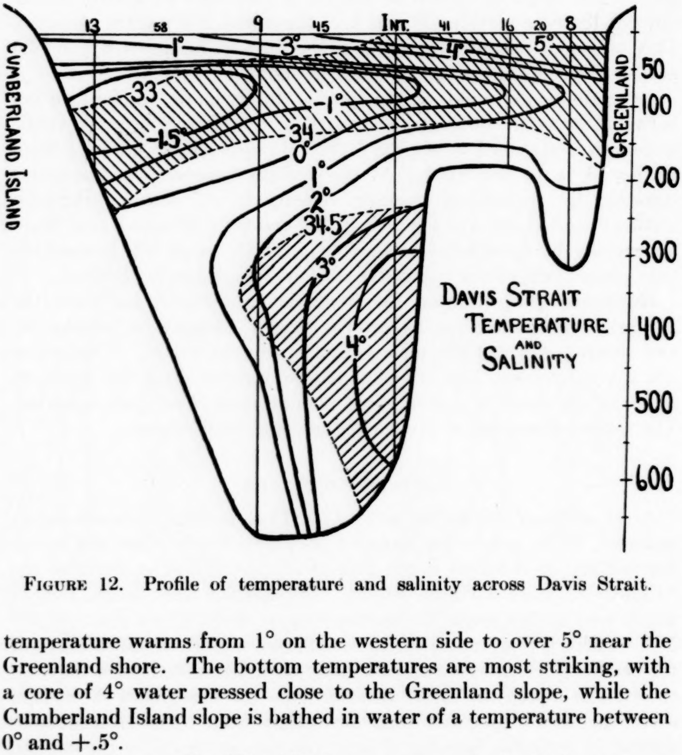

FIGURE 12. Profile of temperature and salinity across Davis Strait.

temperature warms from 1° on the western side to over 5° near the Greenland shore. The bottom temperatures are most striking, with a core of 4° water pressed close to the Greenland slope, while the Cumberland Island slope is bathed in water of a temperature between 0° and $+.5°$.

The salinity profile (Fig. 12) shows comparatively fresh water on both sides of the strait, notably on the western side, where the isohaline of 33 gives a very good picture of the limits of the strength of the south moving current. On the other hand the isohaline of 34.5

corresponds roughly to the isotherm of 3° and marks the limits of water of north Atlantic origin. This core of north Atlantic water, which would not have appeared at all in the section had the interpolated station been omitted, is a northern extension from the mass of oceanic water so noticeable outside the Larbrador Current in more southerly profiles. Its presence at an isolated station (# 14), 120

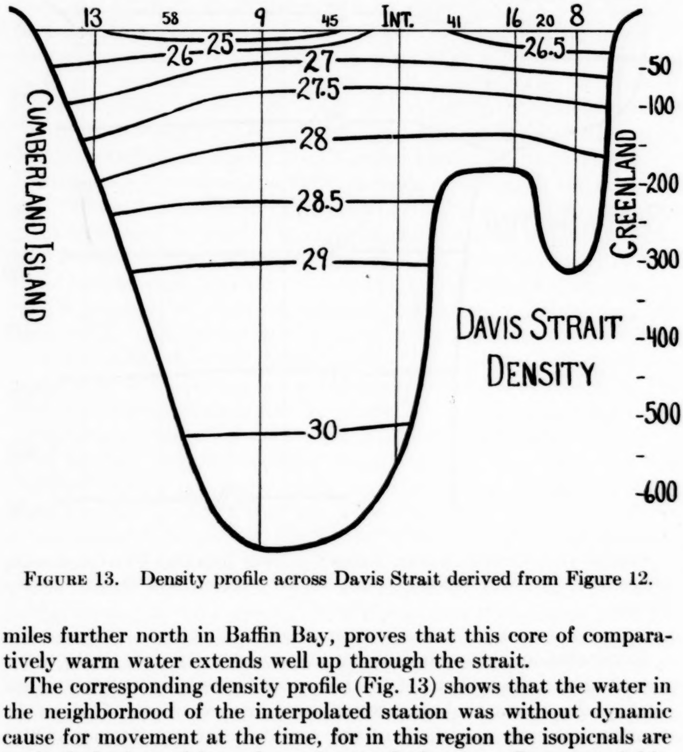

FIGURE 13. Density profile across Davis Strait derived from Figure 12.

miles further north in Baffin Bay, proves that this core of comparatively warm water extends well up through the strait.

The corresponding density profile (Fig. 13) shows that the water in the neighborhood of the interpolated station was without dynamic cause for movement at the time, for in this region the isopicnals are perfectly horizontal from the surface to the bottom. But west of this, the water of the upper 250 meters was being driven southward by a moderate dynamic gradient, with a rise of 14.9 dynamic centimeters in a distance of 58 miles between stations 9 and 13. At this latitude

such a gradient is sufficient to give a velocity of about .2 miles per hour, or 5 miles a day, to the surface waters. But with the stations so far apart, and of very different depths, this calculation can be only an approximation.

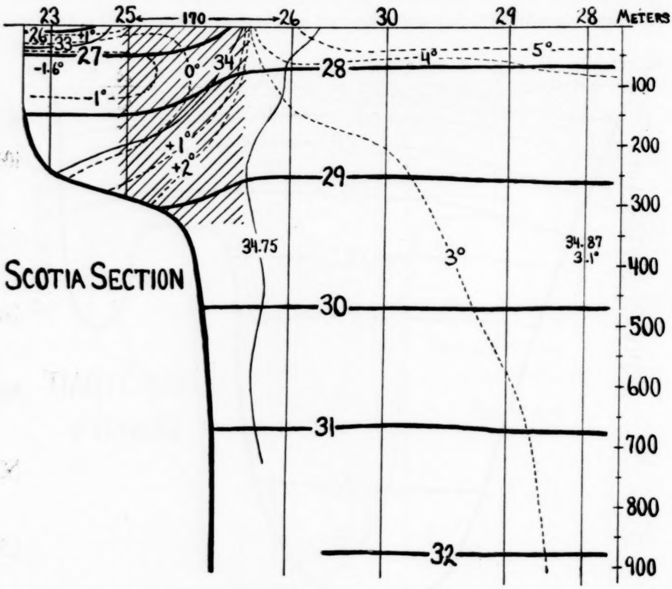

FIGURE 11. "Scotia" section across the lower Labrador Current showing temperature (broken curves), salinity (solid curves), and density (heavy curves).

In conclusion, this section shows that a southerly drift, to be interpreted as the chief source of the Labrador Current, is well developed even as far north as Davis Strait, and pressed closely against the western coast by the effect of the earth's rotation. It has at this northern point almost exactly the same temperatures and salinities as have been observed further south.

"Scotia" Profiles.

All the hydrographic observations which have been discussed so far have been from stations situated in relatively shallow water on the continental shelf. Fortunately the "Scotia" made a line of stations which give us an indication of conditions prevailing near the center of the Labrador Sea. This section, crossing the southern part of the Labrador Current, and running out for 600 miles in a northeasterly direction from the mouth of White Bay, Newfoundland, is based on only six stations. Consequently it gives little more than a general picture of the waters of the region. But this condition is probably equally typical of the off shore waters further north where the "Chance" sections reached only the inner edge of the central mass of oceanic water which bounds the Labrador current on its outer side.

These temperature and salinity profiles, published in the report of the "Scotia" expedition (Matthews 1914), give an impression of great confusion, because of the bending and twisting of the isotherms and isohalines. But when the densities are calculated and plotted these unevennesses are found to counteract each other, and the density curves prove to be nearly horizontal both at their inshore and off-shore ends. Only in the narrow band of the Labrador Current itself does this profile show any dynamic cause for movement. The presence of the mass of motionless water inside the current is explained by the fact that this section was located where the current crosses the large, conspicuous indentation on the northeastern Newfoundland coast.

As in the "Chance" sections, the strength of the current on this "Scotia" profile lay just outside the edge of the continental shelf. Since stations 25 and 26 were 170 miles apart, they give no idea of the actual limits of the current, but we can safely say that it was narrower than this. The shaded area in Figure 11 shows the probable extent of the current at that time. The fact that there is no force indicated in this section to cause movement in the mass of the warmer, off-shore water deserves emphasis, for it indicates that this sector of the Labrador Current is not as wide as it has often been shown on current charts. Consequently, if any of the warmer water outside the edge of the continental shelf was moving southward, it was not being driven by any local dynamic force.

The Labrador Current.

The relative importance of the several possible sources of the Labrador Current must remain in doubt until more sub-surface obser-

vations have been made north of Davis Strait. Either it is an overflow of water from the Arctic Sea which comes south through Kennedy and the other northern channels, or it makes up in Baffin Bay, the necessary water being supplied by the indraft of comparatively warm, salt water along the west Greenland coast. Probably both sources work together to supply the Labrador Current with water, but the latter seems to be the more important because of the narrowness and shallowness of the northern channels.

The conditions in Baffin Bay seem highly favorable for the source of an icy current. We can suppose some such process as the following. Land drainage from the western shores and melting ice supply enough fresh water to account for the low salinity, while the cold winters and the protection of a covering of pack ice throughout the summer allow very little solar warming. Low salinity, in spite of low temperature, reduces the density of the water on the western side of the bay, while on the eastern side a higher density is maintained by the in-flow of North Atlantic water, *via* the West Greenland Current. This contrast is enough to set in operation dynamic forces to urge the western waters of the bay southward.

After the current has passed through Davis Strait, the observations at hand indicate that little change takes place in its volume or in its character until it reaches the Grand Banks, for we find that the cross section of the water colder than 0° measures 10.25 square miles as it passes through Davis Strait, 5.5 square miles off Nachvak, and 12.45 square miles off Sandwich Bay. At first sight the agreement does not seem to be particularly close, but we must remember that the Nachvak section was made three weeks later in the summer than the Sandwich Bay section. Since it was also 330 miles further north, we may add four weeks more to the time interval between the two sections, for at the rate of 12 miles a day it would take the water 28 days to move that distance south. Thus although we found more than twice as much water colder than 0° off Sandwich Bay than off Nachvak, the former represents a seven weeks' earlier stage in the life of the current, which will easily account for the difference, as we must expect a gradual dying off in volume and velocity as the summer advances. Again, it is probable that the current does not flow steadily, but in pulsations. Thus the Davis Strait section may have caught it at a maximum and the Nachvak section at a minimum. However this may be, the profiles prove that the Labrador Current is characterized for a distance of 750 miles, not only by a very similar temperature and salinity dis-

tribution, but also by a volume which remains of about the same order of magnitude from end to end.

After following the length of the Baffin Land coast, the current finds an opening to the right at Hudson Strait. The details of what happens within the latter are yet to be established. Some of the current urged by the rotational effect of the earth, undoubtedly flows in along the Baffin Land side and continues in a northwesterly direction some distance into Hudson Strait. Since the tidal range is great in this region (30 ft.), it is difficult to separate reports of current movements from those of tidal movements in the Straits. The five knot current reported on both sides of Resolution Island is surely chiefly tidal, for in the Labrador Current velocities never greatly exceed one knot for the summer months. But it is safe to say that the outflow from Hudson strait is considerable, since this is the first opening to the right for the counter-clockwise coastal current that has been reported from Husdon bay (Huntsman 1924, p. 275). Finally, it is probable that the circulation in Hudson Strait is dominated by two factors, first, the pumping action of the tides, and second, an actual difference in level between the surface of Hudson Bay and of the open sea off Hudson strait, caused by land drainage into the Bay. These forces result in a discharge into the Atlantic.

Continuing southward, the Labrador Current receives contributions along its inner edge from the streams flowing from the many lakes of Labrador. This addition, the summer temperature of which is between 5° and 8°, apparently supplies enough fresh water to the inside edge of the current to counteract the continual increase in salinity which must take place at the outer edge through mixture with the much more saline oceanic water beyond the continental shelf. A dynamic urge is thus supplied by streams along the whole length of the Labrador Coast. Off Sandwich Bay this coastal current is particularly noticeable, as at that point it has just been reinforced by the water coming out of Hamilton Inlet.

The characteristic temperature (−1° to −1.5°) of the body of the current is maintained by two causes. First, the water layers are so stable vertically, as is shown by the density profiles, that solar warming is but little propagated downward by convection. Second, the many bergs and pack ice transported south from Baffin Bay are continually being melted, both by the stable surface film and by the deeper waters, a process that not only hinders the solar warming of the surface film, but also counteracts what little heat is transferred downward into the deeper waters by vertical currents. The shortness of

the summer months and the fact that sea ice fringes the coast usually until July 1st, are also factors which aid in the thermal isolation of the heart of the current.

In the Straits of Belle Isle, as in Hudson Strait, the current suddenly finds an opening to the right. It has long been observed that each summer many bergs are carried in and grounded on the banks in the strait. Current measurements made in 1894 indicated little inflow of arctic water. But these were made at stations situated half way across the strait, and more recent work (Dawson 1907) revealed a dominant set inward on the north side of the strait and outward on the south side. These sets are weak, probably because of the narrowness of the strait. In all probability such currents would be better developed in Hudson Strait, the mouth of which is 60 miles across.

Having crossed the mouth of the Straits of Belle Isle, the bulk of the Labrador current sweeps on southward, following the edge of the continental shelf across White Bay and Notre Dame Bay, Newfoundland, until it reaches the Grand Banks. Here the greater volume follows the outer edge of the banks, only a small part creeping westward through the gully off Cape Race. Off the "tail" of the Banks, the Labrador Current water meets the much warmer and more saline mass of the Gulf Stream, where its fate has been so thoroughly traced by the work of the ice patrol ships as to need no discussion here.

Probably a fair average for the velocity of the Labrador Current throughout its whole length is 10 miles a day. Spring and summer observations tend to place this somewhat higher. By navigational reckoning the "Chance" found a drift of at least 20 miles a day in the narrow but strong current off Nachvak, and 14 miles per day off Sandwich Bay where the current was wider. The drift of the "Polaris" floe party during the early spring of 1873 averaged 14 miles a day from Cumberland Island to Hamilton Inlet. The early part of their drift through Davis Strait averaged slower than this (9 miles per day), probably owing to the congestion of the pack ice. But all these observations have been made after the spring thaw has given fresh impetus to the current, so that the average velocity for the whole year must be considerably less. In winter, with the dying out of the land drainage, the prevailing northwest wind probably does much to keep the current moving. As at that time of year the coastal strip is protected by a covering of pack ice, it would be interesting to know whether the strong winter winds also set some of the water outside the edge of the continental shelf moving southward.

In conclusion, the Labrador Current may be classed as a long

narrow stream of coastal water, the character of which is maintained throughout its length by land drainage, favoring winds and melting ice. This coastal current is in sharp contrast with the warmer, more saline, water in contact with its outer edge. The latter is part of the homogeneous central core of the Labrador Sea, and is apparently affected by no physical factors strong enough to set up important dynamic movements.

Bays and Fiords of Newfoundland and Labrador.

During the cruise of the "Chance" several of the bays and fiords of the Newfoundland and Labrador coasts were visited. In some of these subsurface temperature and salinity observations were made, and their discussion is of interest because there exist no other data giving

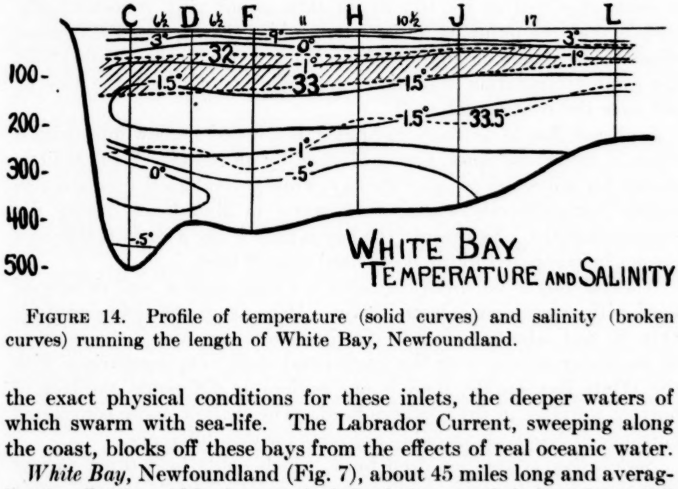

FIGURE 14. Profile of temperature (solid curves) and salinity (broken curves) running the length of White Bay, Newfoundland.

the exact physical conditions for these inlets, the deeper waters of which swarm with sea-life. The Labrador Current, sweeping along the coast, blocks off these bays from the effects of real oceanic water.

White Bay, Newfoundland (Fig. 7), about 45 miles long and averaging 9 miles in width, is a typical fiord, its mouth being about 210 meters deep while its head is in places as deep as 500 meters. The hydrographic profile (Fig. 14), made July 19 to 21, runs the length of the inlet and shows very much the same vertical distribution of temperature and salinity as existed outside in the Labrador Current. The isotherms and isopicnals, slanting towards the upper end of the bay, indicate that there the surface waters were slightly heaped up.

This probably was the result of the wind which blew steadily towards the head of the bay during the visit of the "Chance."

The stratum of coldest water ($-1.5°$), which is seen at a depth of from 100 to 200 meters, is an interesting feature of this inlet, for such a band of icy water is also found in the Gulf of St. Lawrence (Sandström 1919, p. 290) and everywhere over the Labrador continental shelf where the depth is great enough for its development. This coldest, intermediate water must have its origin during the winter, and is protected during the summer months from the sun by the exceedingly stable, fresher surface layer.

White Bay has a wide (14 mile) mouth, and there is every reason to expect that there is a certain amount of interchange between its waters and the Labrador Current outside. No dynamic evidence of this can be found from the "Chance" survey, but since there were several bergs well up the bay at the time of our visit, it seems fairly certain that the pumping action of the tides (Huntsman 1923) must effect a slow steady circulation of the upper water layers. Thus about the same temperature conditions are maintained inside the bay as out over the continental shelf.

Sandwich Bay in southern Labrador, is a broad shallow inlet with a shoal (6 meter) entrance, partly blocked by an island. There is little chance for salt water to enter the bay, while several good sized streams supply comparatively warm, fresh water in abundance during the summer months. As a result, the bay is practically a shallow lake and cannot be compared to the deep, fiord type of inlet.

Nachvak Bay in northern Labrador is a long, narrow, well developed fiord with steep mountainous shores. Here again the temperature—(Fig. 8) and salinity—(Fig. 9) distribution is very much the same as in the water outside over the continental shelf. On comparison with the White Bay profile, there is one noticeable difference, the lack of bottom warming in the northern fiord. The shallow, more contracted entrance of Nachvak probably accounts for this difference.

Seglek Bay is another deep fiord, which splits into three narrow branches about ten miles back from the coast. The "Chance" made two stations in this fiord, from which it is evident that conditions closely resemble those found in Nachvak. A more northern inlet, Ekortiarsuk, being mostly shallower (60 meters) contained no water colder than 1.1° C, or more saline than 32.3 parts per thousand.

A striking feature of all Labrador fiords is the surface film of nearly fresh water. During the summer there is much land drainage in this region and these waters flow out on the surface of the fiords. The

result is that the surface is nearly barren of life and the beaches remind one much more of a lake than of a sea coast.

A comparison with the conditions found in the Norwegian fiords is instructive of the differences existing on the two sides of the Atlantic. The deeper parts of the Norwegian fiords are filled with much warmer (2°–6° C) and more saline (34 to 35 parts per thousand) water, and there exists no barrier such as the Labrador Current to cut them off from the oceanic waters, while the milder winters never greatly chill their depths (Nordgaard 1905).

PHYTOPLANKTON.

The surface plankton-hauls listed below (page 27) were made during July and August 1926 in the bays and coastal waters of the Labrador and Newfoundland coasts. The net was of #20 silk with a diameter of half a meter at its mouth. The length of each tow was approximately one half hour. The richness of the hauls has been expressed as the number of cubic centimeters of living matter which settled in the jars after formalin had been added, and these figures are recorded along with the position of the stations on page 37.

With respect to the physical conditions of the water, the hauls can be classified into three groups: first, those made in the bays or fiords where the surface temperature varied from 6° to 8° and the salinity from about 25 parts per thousand to nearly fresh water; second, those made within about 10 miles of the coast where the temperature was still under the influence of the comparatively warm bay waters, but where the salinity was perhaps as high as 31 per thousand; and third, those made off shore in the Labrador Current proper where the surface temperatures were not over 3° and the salinity about 32 parts per thousand. But when the hauls themselves are examined they do not readily split up into these three divisions, showing that within a comparatively wide range, temperature and salinity do not control either the variety of the forms or their abundance in this region.

In the first four hauls made at the surface in or near White Bay, Newfoundland, we found almost no diatoms. The physical characteristics of the water at station 1 and 2 were apparently not very different from more southern stations where the diatoms were relatively abundant, so we can only suggest that these two hauls were made before the summer production occurred.

Three other hauls (8, 9, and 17) from Seglek Bay in northern Labrador, were also barren of diatoms. In this case the most reason-

able explanation is that there the excessive land drainage flowing into the narrow fiord had produced such a stable surface layer that almost no vertical circulation could take place and thus few organisms were carried upward from the more saline deeper waters. It is probable that if our tows had been made at 10 meters, we would have escaped the too light surface films and secured a more reliable picture of the distribution of the diatoms along the Labrador coast.

The list of species identified in these 18 hauls is not complete, a few of the brakish water and bottom living forms having been omitted since they were observed only once or twice and were not typical of the coastal waters near the surface. The fact that the most northern fiords, near Cape Chidley, have a greater tidal range than the more southern bays, and are not so thoroughly blocked by the inshore current of low salinity, is reflected by the greater variety of their phytoplankton. For example, two oceanic forms, *Rhizosolenia styliformis* and *Coscinodiscus asteromphalus*, which occurred at Eclipse Harbor (14) and in Ecortiasuk Bay (15 and 16) are as good proof that offshore water comes into the northern inlets as are the higher salinities found there in the course of the hydrographic investigations. Three other oceanic forms were sparsely scattered well inshore, *Chaetoceras atlanticum*, *Ch. densum*, and *Thalassiothrix longissima*. Their presence near the land points to a continuous addition of oceanic water all along the outer edge of the Labrador Current and a thorough mixture of this salter water even in as far as the fresh coastal stream.

The "Chance" found 41 species of phytoplankton, and 3 infusorians fairly common in the Labrador Current waters. Of these, 24 species have been reported by Gran (1919) from the Gulf of St. Lawrence and 22 species are listed by Crawshay (1924) from the region of the Grand Banks. More recent work in Davis Strait (Gran 1929) shows only 22 of the "Chance" forms near the source of the current. An even more striking fact is that 30 of the "Chance's" list have been reported from the Gulf of Maine (Bigelow 1926) and 26 from the Norwegian fiords (Jorgensen 1905). All this shows that relatively few of the forms are definitely arctic. The fact that so many species common off Labrador are also common in the Gulf of Maine, and in the Norwegian fiords, is evidence that temperature and salinity are of minor importance in the distribution of these tiny organisms.

Although the "Chance" did not make quantitive measurements, it is evident from the volume of plankton obtained at each station, that nowhere was there an exceptional flowering of diatoms taking

place. The average winter catch in the Gulf of Maine, before the great spring flowering, is in the neighborhood of 3 cc. Although the "Chance" used identical nets and towed for the same length of time (30 minutes) at each station, many of her catches did not greatly exceed this figure. In fact only at one station (5) could the Labrador diatoms be called really abundant. On the whole then, the surface microplankton of Labrador coastal waters was found to be relatively poor during July and August.

NOTES ON INDIVIDUAL SPECIES.

The species verified by Dr. Albert Mann are marked with asterisks.

Diatoms.

1. *Acnanthes taeniata* Grun. Occurred at four of our stations along the Labrador coast. [5, 6, 10, and 14].

2. **Bacterosira fragilis* Gran. Was found at only two of the northern stations, 10 and 14.

3. **Biddulphia aurita* (Lyng.) Breb. Several examples of this form were observed in the sample from station 5, off Sandwich Bay.

4. **Chaetoceras atlanticum* Cleve. Was found in moderate quantities in over half the samples examined (1, 2, 3, 6, 7, 11, 13, 14, and 16).

5. **Ch. boreale* Bailey. Observed in our material in small numbers at only one station (6) 75 miles off Sandwich Bay.

6. **Ch. constrictum* Gran. Found in considerable numbers at station 5.

7. **Ch. contortum* Schutt. Encountered once in abundance eight miles east of Cape Harrison (7) and in smaller numbers at 9 stations along the coast and in the most northern fiords (5, 6, 10, 11, 13, 14, 15, 16, and 18).

8. **Ch. criophilum* Cast. Abundant 14 miles off the mouth of Nachvak fiord with scattered specimens from 5 other coastal stations (5, 6, 13, 14, and 16).

9. **Ch. curvisitum* Cleve. Dr. Mann lists this form as frequent from one station (5).

10. **Ch. debile* Cleve. Although Gran (1929) lists this as "the commonest of all diatoms in August" in Davis Strait, it was only found by the "Chance" at the surface in three of the northern fiords, stations 11, 14, and 16.

11. **Ch. decipiens* Cleve. Found abundantly 75 miles off the southern Labrador coast (no. 6) and again 14 miles east of Nachvak Fiord. It also occurred in small numbers at 9 other stations (1, 5, 7, 10, 11, 13, 14, 16, and 18).

12. **Ch. densum* Cleve. Occurred in small numbers at 7 of the coastal stations (6, 7, 12, 13, 14, 16, and 18). This oceanic form can evidently only flourish where considerable oceanic water has been mixed with the fresher arctic stream.

13. **Ch. diadema* (Ehr.) Gran. Observed in abundance both off Sandwich

Bay (5) with endocysts and in Nachvak Fiord (11) and in small quantities at 6 other stations (7, 10, 13, 14, 16, and 18).

14. **Ch. laciniosum* SCHUTT. Scarce at station 5 off Sandwich Bay.

15. **Ch. sociale* LAUDER. Found in great numbers at station 16 (Ekortiasuk) and sparsely at four other stations (5, 11, 14, and 15).

16. **Ch. teres* CLEVE. Scattered in small numbers through the catch of but four stations (5, 11, 13, and 16).

17. **Coscinodiscus asteromphalus* EHR. Identified by Dr. Mann in small numbers from station 16 (Ekortiasuk) and occurring even more sparsely at stations 14, 15 and 18).

18. **Detonula confervacea* (CLEVE) GRAN. A few examples found in the material from station 5 by Dr. Mann.

19. **Fragilaria islandica* GRUN. This form has not previously been reported from neighboring waters. It occurred commonly at station 5 off Sandwich Bay and more scarcely at stations 10, 11, 12, 13, 14, and 16.

20. **F. striatula* LYNG. In small numbers at stations 10, 12, 14.

21. **Lauderia glacialis* GRUN. Found sparsely scattered (with endocysts occasionally) at stations 5, 11, 12, 13, 14, 15, and 16.

22. **Melosira nummulus* MUEN. A few specimens were identified from three of our stations (6, 8, and 10).

23. **Navicula transitans* CLEVE. A few specimens found at station 16 by Dr. Mann.

24. *Nitzschia seriata* CLEVE. This form was very scarce being found in only 6 of our hauls (5, 7, 11, 13, 14, and 18).

25. **Rhizosolenia setigera* BRIGHT. Found, never in large numbers, at 9 of the stations (1, 2, 10, 11, 12, 13, 14, 16, and 18).

26. **Rh. styliformis* BRIGHT. A few specimens collected at three points (12, 14, and 16) along the northern Labrador coast.

27. **Sleletonema constatum* (GREV.) CLEVE. In great abundance at station 5, off Sandwich Bay, but not collected from any other locality.

28. *Synedra pulchella* KUTZ. A few specimens identified from station 16.

29. **Thalassiosira decipiens* (GRUN) JORG. Collected in very small numbers at stations 5, 6, and 14.

30. *Th. gravida* CLEVE. Observed occasionally at stations 11, 13, 14.

31. **Th. Nordenskjoldii* CLEVE. The dominant form at stations 11, 13 and 14 and occurring in small numbers at 6 other stations (5, 7, 10, 12, 16 and 18).

32. *Th. subtilis* (OST.) GRAN. Observed only just inside the mouth of Nachvak Fiord (11).

33. **Thalassiothrix longissima* CLEVE ET GRUN. This oceanic species occurred at 7 coastal stations (5, 6, 11, 12, 13, 14, and 15).

34. **Th. nitzschioides* GRUN. Common at three localities (5, 10, and 16).

SILICOFLAGELLATES.

35. *Distephanus speculum* (EHR). A few specimens were identified from four localities (9, 10, 11, 13).

Peridinians.

36. *Ceratium arcticum* Bailey. This arctic species was found in all the samples. It completely dominated the hauls from stations 3, 4, and 13; was abundant at five other localities (6, 8, 9, 12, and 18), and occurred in moderate numbers in the other samples. All the samples were carefully examined for *C. longipes*, but no specimen was seen which could not be called *C. arcticum*.

37. *Dinophysis norvegica* Clap. et Lachm. Throughout the whole area at almost every station, but not common at any one locality.

38. *Peridinium depressum* Bailey. Found abundantly at stations 6, 8, 9, and 17 and in smaller numbers at all but four of the remaining stations.

39. *P. ovatum* Pouchet. In moderate numbers in all but four of the hauls.

40. *P. pellucidum* (Bergh.) Schutt. Found in considerable numbers at station 1 and more sparsely at all but 4 of the other stations.

Infusorians.

41. *Cyttarocylis denticulata* Ehr. Collected at all but one station. At station 12, off Nachvak Bay, this form was abundant enough to dominate the catch.

42. *Ptychocylis urnula* Clap. et Lachm. In small numbers at all but two of the northern stations (15 and 18).

43. *Tintinnopsis sp.* Possibly *Tintinnopsis urnula*. This form was dominant at station 10 and occurred at 4 other localities (8, 9, 11, and 15).

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LIST OF HYDROGRAPHIC STATIONS.

Station	Latitude	Longitude	Depth	Temperature	Salinity	Density
			CAPE RACE SECTION.			
A	46° 25′ 30″	52° 22′	0	8.05°	31.80	24.79
			10	8.0°	32.00	24.95
			40	3.3°	32.80	26.15
			75	−0.22°	33.16	26.65
B	46° 32′	52° 34′	0	8.1°	31.40	24.47
			20	7.2°	32.05	25.11
			45	−0.85°	33.00	26.56
			90	−1.36°	33.13	26.67
			200	−1.12°	33.40	26.88
C	46° 38′	52° 44′	0	7.5°	31.36	24.52
			20	7.6°	31.98	25.00
			50	−0.63°	33.01	26.55
			70	−1.18°	33.08	26.62
			125	−0.62°	33.15	26.67
			200	−1.14°	33.36	26.85
D	46° 45′	52° 54′	0	6.72°	31.28	24.57
			20	5.9°	31.80	25.17
			35	0.7°	32.60	26.16
			60	−1.08°	33.01	26.56
			WHITE BAY.			
A	50° 13′ 30″	56° 7′ 30″	0	12.89°	——	——
			20	4.2°	29.94	23.77
			50	−0.67°	32.29	25.97
			100	−1.44°	33.03	26.59
			200	−1.32°	——	——
			300	−0.26°	33.78	27.17
B	50° 6′	56° 17′	0	9.44°	——	——
			20	0.28°	31.29	25.12
			50	−1.25°	32.56	26.20
			100	−1.38°	32.95	26.53
			200	−1.50°	33.24	26.77
			300	−0.42°	——	——
C	49° 47′	56° 42′	0	10.56°	28.06	21.54
			20	3.0°	30.28	24.32
			50	−0.05°	31.56	25.36
			100	−1.38°	32.79	26.40
			200	−1.36°	33.21	26.73
			280	0°	33.68	27.06
			480	−0.56°	33.91	27.28

Station	Latitude	Longitude	Depth	Temperature	Salinity	Density
D	49° 53′	56° 37′	0	9.89°	——	——
			20	2.5°	30.34	24.37
			50	−0.53°	31.92	25.65
			100	−0.62°	32.83	26.38
			200	−0.74°	33.21	26.68
			300	−0.37°	33.77	27.13
			400	−0.10°	33.78	27.15
E	49° 57′	56° 39′	0	10.17°	——	——
			20	2.57°	29.79	23.49
			50	−1.0°	32.36	26.04
			100	−1.30°	32.81	26.41
			200	−1.83°	33.19	26.73
			295	−0.41°	33.68	27.09
F	49° 59′	56° 32′	0	10.5°	——	——
			20	3.55°	29.92	23.83
			50	−0.54°	31.96	25.70
			100	−1.22°	32.88	26.46
			200	−1.58°	33.13	26.68
			300	−0.56°	——	——
			400	−0.27°	33.69	27.08
G	50° 0′	56° 35′	0	9.39°	——	——
			20	4.4°	30.07	23.68
			50	−0.63°	31.91	25.66
			100	−1.42°	32.79	26.40
			200	−1.54°	33.24	26.77
			300	−0.10°	33.62	27.02
H	50° 8′	56° 22′	0	9.83°	——	——
			20	3.7°	30.00	23.70
			60	−1.05°	——	——
			160	−1.5°	33.32	26.83
			260	−1.18°	33.79	27.20
			360	−0.1°	33.69	27.07
I	50° 10′	56° 27′	0	8.56°	——	——
			20	4.37°	30.32	23.89
			60	−1.14°	32.39	25.99
			140	−1.54°	33.28	26.79
			240	−1.0°	33.53	26.98
			340	−0.18°	33.75	27.13
J	50° 16′ 30″	56° 13′	0	7.95°	——	——
			20	5.1°	30.27	23.96
			60	−1.40°	32.68	26.31
			140	−1.55°	33.20	26.33
			240	−1.1°	33.68	27.11
			340	−0.10°	33.97	27.30

Station	Latitude	Longitude	Depth	Temperature	Salinity	Density
K	50° 19′ 30″	56° 19′ 30″	0	8.67°	——	——
			20	4.5°	30.43	24.13
			60	−0.92°	32.17	25.87
			120	−1.6°	33.08	26.64
			220	−1.2°	33.63	27.07
			320	−0.2°	33.98	27.32
L	50° 32′	55° 58′ 30″	0	8.83°	——	——
			10	6.44°	30.66	24.22
			20	3.57°	30.97	24.65
			50	−1.42°	32.91	26.49
			100	−1.7°	33.39	26.89
			200	−1.3°	33.74	27.16

Sandwich Bay Section.

Station	Latitude	Longitude	Depth	Temperature	Salinity	Density
A	55° 33′	54° 12′	0	6.3°	34.32	27.00
			20	6.1°	34.29	27.01
			50	3.78°	34.67	27.57
			100	4.32°	34.52	27.43
			250	3.80°	34.76	27.62
			300	3.52°	34.85	27.74
B	55° 10′	54° 45′	0	1.0°	32.66	26.18
			20	0.46°	33.06	26.54
			50	−1.22°	33.37	26.77
			100	−1.0°	33.86	27.24
			200	−0.3°	33.84	27.20
			250	−0.4°	33.70	27.10
C	54° 54′	55° 8′	0	1.7°	31.94	25.57
			20	0.8°	32.10	25.77
			50	−1.8°	33.04	26.61
			100	−0.87°	33.57	27.01
			200	−0.58°	33.76	27.15
D	54° 38′	55° 30′ 30″	0	3.4°	31.96	25.46
			20	3.4°	31.97	25.47
			50	−0.3°	32.48	26.12
			100	−1.1°	33.82	27.23
			150	−1.0°	33.86	27.24
E	54° 28′ 30″	55° 43′	0	2.2°	31.46	25.27
			20	1.1°	31.95	25.67
			50	−1.3°	32.83	26.38
			100	−1.6°	33.15	26.64
			200	−1.4°	33.32	26.78
			250	−0.9°	——	——

Station	Latitude	Longitude	Depth	Temperature	Salinity	Density
F	54° 19′ 30″	55° 55′	0	2.9°	30.99	24.72
			20	−0.8°	32.28	25.97
			50	−1.6°	32.93	26.51
			150	−1.2°	——	——
			250	−0.3°	——	——
			300	0.1°	34.32	27.57
			400	1.42°	34.50	27.64
G	54° 8′	56° 11′	0	3.3°	30.87	24.60
			20	2.5°	31.41	25.09
			50	−1.6°	32.92	26.51
			100	−1.6°	33.07	26.63
			125	−1.56°	33.14	26.69
			150	−1.58°	33.24	26.76
H	53° 58′	56° 27′	0	5.4°	29.45	23.32
			20	−1.0°	32.40	26.07
			50	−1.8°	32.96	26.55
			125	−1.65°	33.00	26.58
I	53° 55′	56° 43′	0	8.2°	25.12	19.55
			10	5.0°	——	——
			20	3.2°	28.19	22.48
			55	−1.55°	32.81	26.41
			Nachvak Section.			
A	59° 4′	63° 56′ 30″	0	6.6°	——	——
			10	−0.3°	31.37	25.22
			20	−0.95°	31.67	25.48
			50	−1.6°	32.96	26.55
			70	−1.6°	32.94	26.52
B	59° 1′ 15″	63° 42′	0	4.8°	——	——
			10	−0.48°	31.37	25.23
			25	−0.9°	32.33	26.01
			75	−1.63°	32.80	26.40
			150	−1.8°	33.20	26.72
C	59° 4′	63° 26′	0	4.1°	——	——
			10	−0.3°	31.52	25.34
			20	−0.21°	31.76	25.53
			50	−0.02°	32.02	25.73
			100	−1.83°	33.12	26.67
			200	−1.8°	33.20	25.73
D	59° 11′ 30″	63° 13′	0	2.4°	31.86	25.46
			10	0.8°	31.89	25.57
			20	0.84°	32.01	25.67
			50	0.2°	——	——
			100	−0.45°	32.41	26.06

Station	Latitude	Longitude	Depth	Temperature	Salinity	Density
E	59° 17′ 30″	62° 57′ 30″	0	4.0°	31.30	24.88
			20	1.7°	31.45	25.18
			50	−1.25°	32.41	26.09
			100	−1.2°	33.02	26.58
			125	−1.2°	33.07	26.61
F	59° 25′	62° 32′ 30″	0	4.5°	31.32	24.85
			20	0.6°	31.54	25.30
			50	−0.2°	32.11	25.80
			125	−0.88°	33.21	26.72
G	59° 36′	61° 58′	0	3.45°	31.35	24.97
			20	2.38	31.50	25.16
			50	−0.1°	32.54	26.14
			100	−0.8°	32.96	26.51
			150	−0.8°	32.99	26.54
H	59° 46′ 30″	61° 25′	0	3.3°	31.35	24.97
			20	−0.1°	32.00	25.71
			50	−0.4°	32.24	25.92
			100	−0.68°	32.71	26.31
			125	−0.6°	32.82	26.39
			150	−0.6°	32.90	26.46
			200	−0.45°	32.98	26.52
J	59° 53′	61° 6′	0	2.3°	32.89	26.29
			20	0.1°	——	——
			50	--0.1°	33.22	26.70
			100	0.15°	33.50	26.91
			150	0.7°	33.78	27.11
			200	1.3°	34.07	27.30
			250	1.8°	34.30	27.50
I	59° 59′	60° 45′	0	5.3°	34.10	26.95
			20	5.15°	34.02	26.92
			50	2.18°	34.04	27.21
			100	2.37°	34.42	27.49
			150	2.6°	34.50	27.54
			200	3.5°	34.67	27.59
			250	4.2°	34.74	27.57
			300	4.8°	34.78	27.55
			400	4.9°	34.83	27.56
			FIORDS.			
	59° 54′	64° 23′	0	1.9°	31.58	25.27
			10	1.5°	31.80	25.47
	EKORTIARSUK		20	1.1°	32.08	25.72
			50	1.1°	32.27	25.87
	SEGLEK, North Arm		0	6.6°	——	——
			40	−1.3°	31.76	25.56

LIST OF SURFACE PLANKTON HAULS

Station	Latitude	Longitude	Date	Volume	Locality
1	49° 30′	53° 15′	July 16	5	14 miles SSW of Funk Island
2	49° 55′	54° 50′	July 16	18	Off Notre Dame Bay
3	49° 53′	56° 37′	July 19	21	Station D, White Bay
4	49° 59′	56° 32′	July 20	30	Station F, White Bay
5	53° 53′	56° 40′	July 25	105	Just off Sandwich Bay
6	54° 50′	55° 10′	July 27	37	75 miles east of Sandwich Bay
7	55° 2′	57° 50′	August 3	7	8 miles east of Cape Harrison
8	58° 33′	63° 48′	August 11	22	North arm of Seglek Bay
9	58° 33′	63° 36′	August 11	3	Seglek Bay
10	59° 3′	63° 52′	August 18	3	Nachvak Bay
11	59° 1′	63° 42′	August 18	30	Station B, Nachvak Bay
12	59° 14′	63° 0′	August 18	12	14 miles east of Nachvak Bay
13	59° 37′	61° 15′	August 20	15	70 miles east of Nachvak Bay
14	59° 51′	64° 9	August 27	18	Off Eclipse Harbor
15	59° 45′	64° 46′	August 29	7	Near head of Ekortiarsuk Bay
16	59° 53′	64° 20′	August 31	45	Station A, Ekortiarsuk Bay
17	58° 33′	63° 48′	August 10	22	North Arm of Seglek Bay
18	58° 40′	62° 38′	September 3	18	5 miles east of Seglek Bay